Joint ACCESS

High Speed Assault Connector

TSSE Design Team
Naval Postgraduate School
Joint Seabased Theater Access Workshop
February 2005

Amphibious Combat Cargo Expeditionary Support Ship

TSSE

- Program started in 1992
- “Systems Engineering” based
- Option area, students from:
  - Mechanical Eng.
  - Electrical Eng.
  - Combat Systems
  - Other (SE, OR)
- 6 “core” courses plus 2-quarter design project
- Nominal 25% load
- Students
  - ED and URL mix
  - US and International mix
  - Services mix
- Typically 8-12 students per year
- Recent “Cooperative engagement” with SEA

The scope of TSSE

- TSSE produces:
  - Mechanical engineers with a working knowledge and appreciation of requirements generation, systems thinking, power distribution, and combat systems and how all of the above impact naval ship design
  - Similarly for the CS and EE students
- It does not produce:
  - Naval ship designers to the extend that the MIT 13A program does
  - Combat Systems engineers
  - Power system engineers
  - Systems engineers

However, TSSE produces graduates with adequate foundation to become one of the above.

SEA-6 Key Results

- 2004 Expeditionary forces cannot meet a 10/30/30 timeline with a brigade-sized force.
- 2015 Sea Base Programs of Record better, but still short of a 10/30/30 timeline
- Requires “dedicated” lift assets in order to seize the initiative within 10 days
- Rapid force employment hindered by multiple at-sea transfers
- Promising 2015-2025 proposals:
  - Dedicated Strategic Lift Assets
    - High-speed surface ships - RSLS
    - Lighter-than-air ships
  - Force Employment Assets
    - Large-payload, high-speed connectors
    - Load-once, direct-to-objective connectors
- For further study
  - SEABASE-6 analytical computer model is a viable tool for further analysis
  - MPF(F), RSLS, airship survivability and reliability
  - Sea Base command structures

Request

- A conceptual design for a High Speed Assault Connector (HSAC) to enhance Joint Expeditionary Logistics (JELo) flow from the Sea Base to shore
- Augment or replace existing connector platforms
- Employment requirement
  - Cargo: ~8000LT of vehicles, troops, and gear
  - Distance: 200nm from the Sea Base to shore
  - Time: 10 hours
  - Sea state: 4
  - Interface: accept cargo and troops at the Sea Base and deliver to shore

Design Solution

- A system of 12 HSACs that fill all the previous connector requirements
- Each HSAC is multi-mission capable, self-sustaining, and:
  - Can accommodate embarked troops, cargo, and gear from FLS and or/CONUS to the Sea Base
  - Can transit 2000nm @20kts (fully loaded) w/40% fuel remaining
  - Has defensive and offensive combat capabilities

Initial Requirements

- SEA-6
  - Transport JEB from the Sea Base to shore
  - Time limited to a 10 hour period
  - Interface with Sea Base, developed ports, and austere beaches
- TSSE Faculty
  - Support amphibious operations ashore in addition to delivering payload
  - Conduct secondary missions
  - Capable of independent operations

Beachable/Non-Beachable

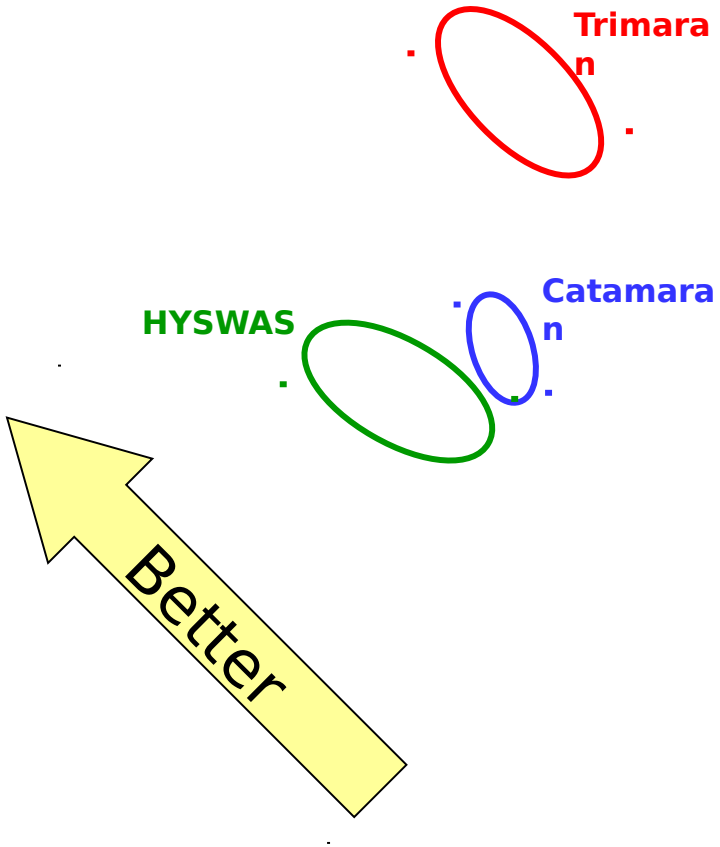
- Considered two delivery methods
  - Non-Beachable (LCAC ferry)
    a. Pros
    b. Cons
  - Beachable
    a. Analysis Newport class LST
    b. Pros
    c. Cons

After feasibility study beachable was selected

Analysis of Alternatives

- Developed 3 Measures of Performance (MOP)
- Analytic Hierarchy Process (AHP) was used to set the weights
  - Transport factor – 43%
  - Survivability – 43%
    - Number of ships – 50%
    - Overall ship length – 30%
    - Speed – 20%
  - Mission flexibility – 14%
    - Payload – 30%
    - Draft – 30%
    - Number of ships – 20%
    - Speed – 20%
- Overall MOP weighted sum of the individual MOPs
- Design of Experiments
  - 7 x 9 x 5 Design matrix
    - 7 different hull types
    - 9 different payloads
    - 5 different speeds
  - Total of 315 possible designs

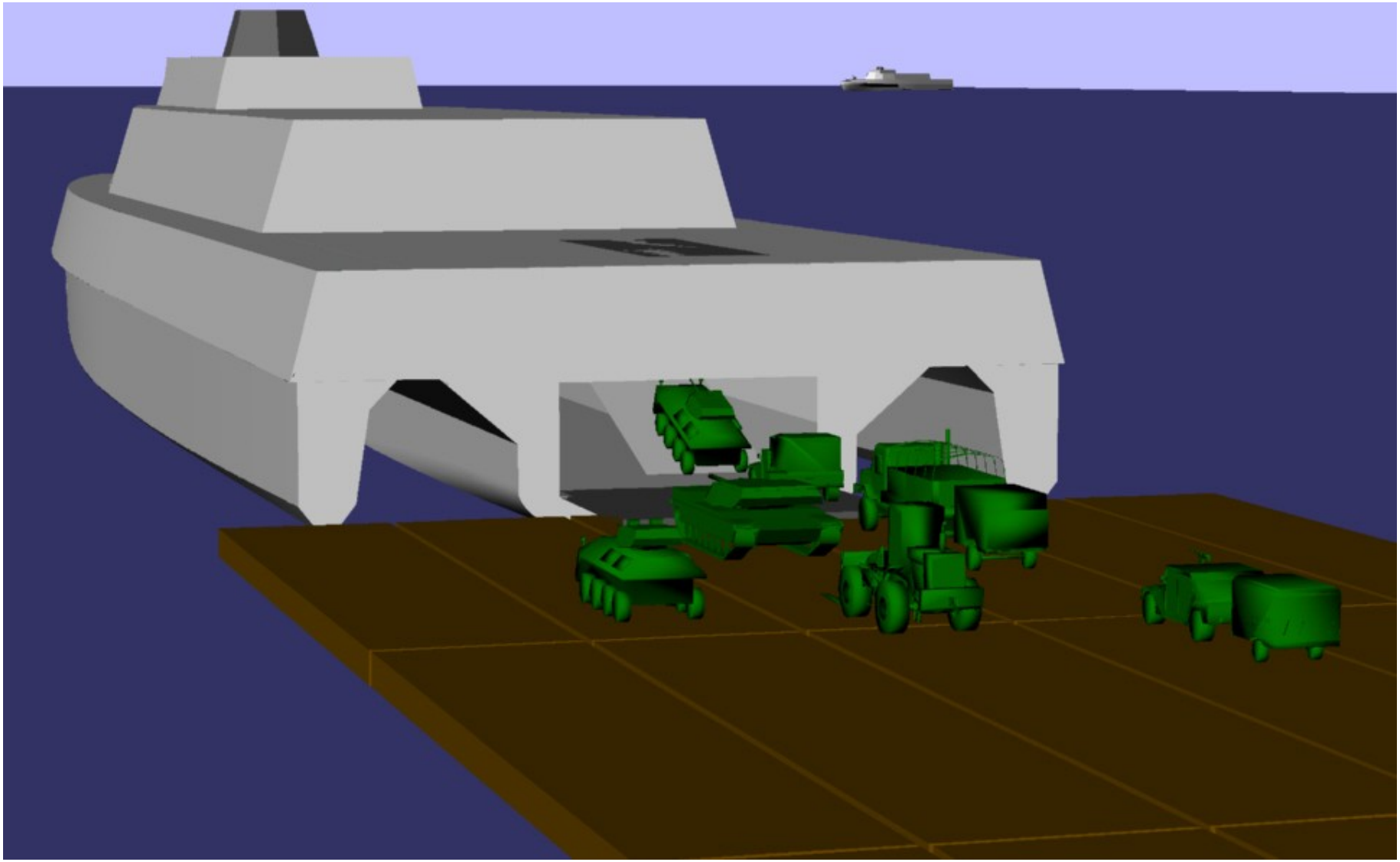
AoA: MOP vs Cost



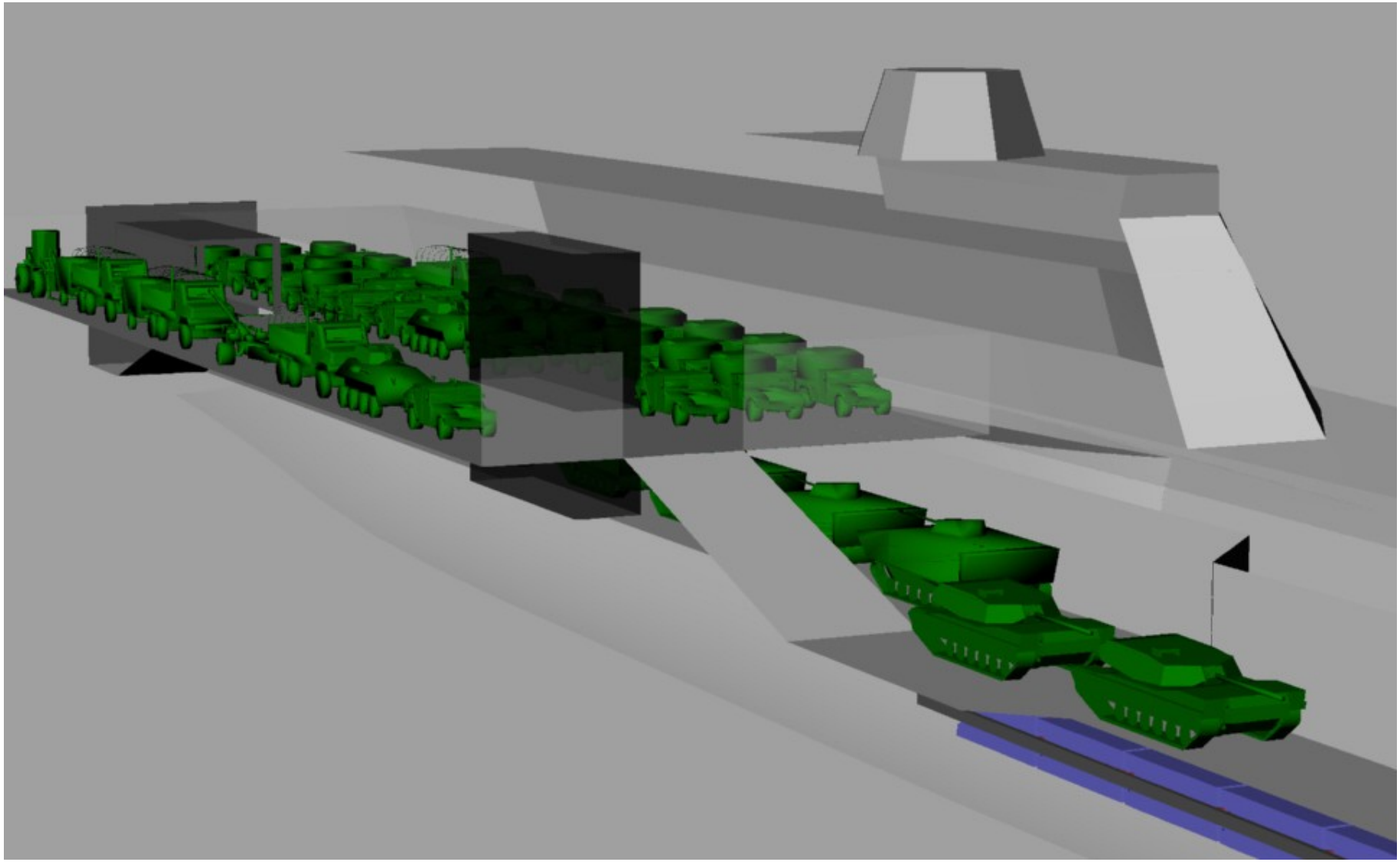
Cargo Requirements

- Transport surface components of 2 Battalion Landing Teams
  - 204 Humvee
  - 98 EFV
  - 21 M1A2
  - 4 AVB
  - 2 AVLB
  - 8 M9ACE
  - 2 M88A2
  - 16 ITV
  - 10 Avengers
  - 38 MTVR
  - 12 LW155
  - 16 M105
  - 6 MK155
  - 34 M101
  - 2 M149
  - 2 M116
  - 2 AN/TPQ
  - 8 4K Forklifts
  - 4 Contact trucks
- A total of 546 vehicles delivered in first 10 hours

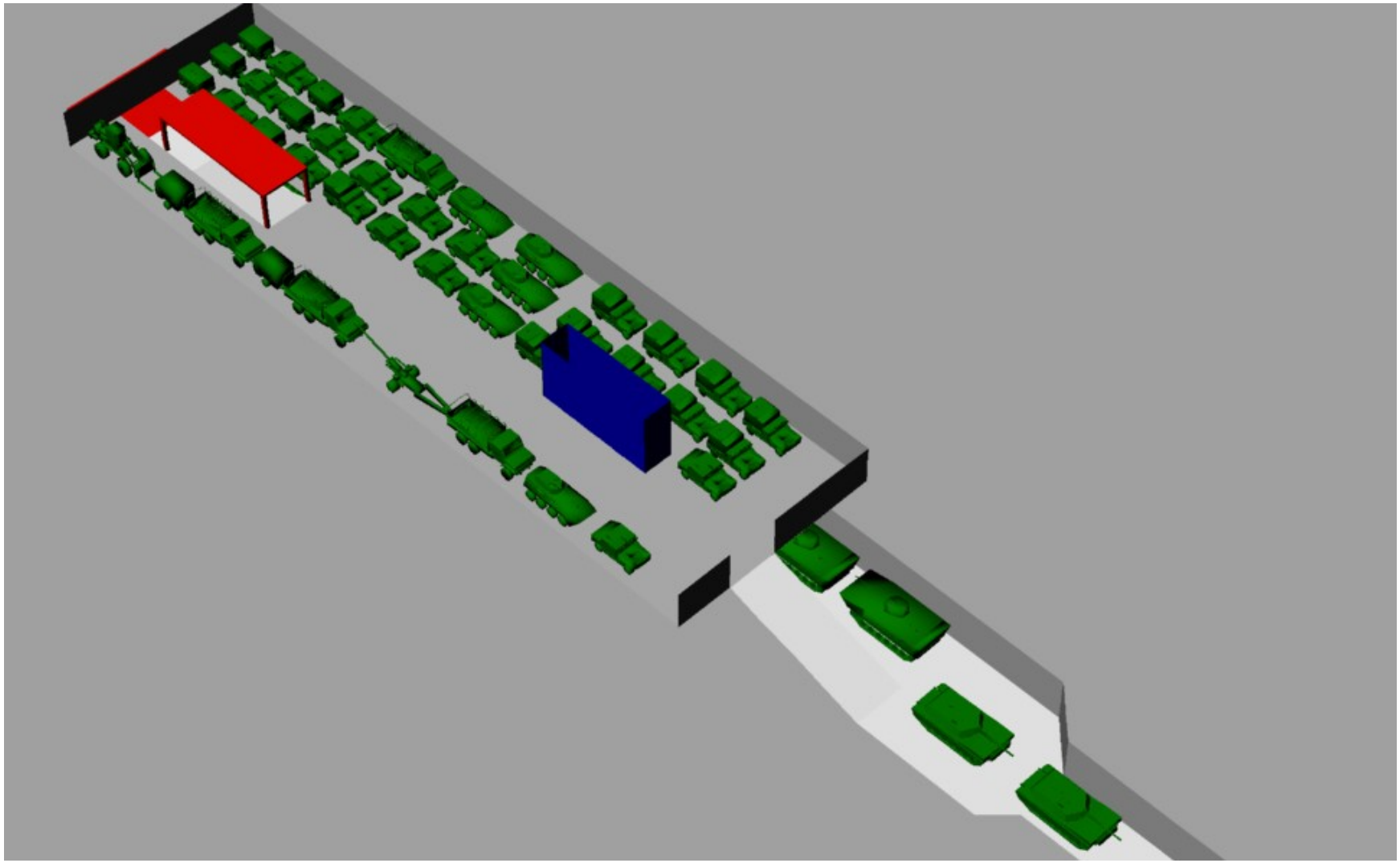
Stern Gate Loading



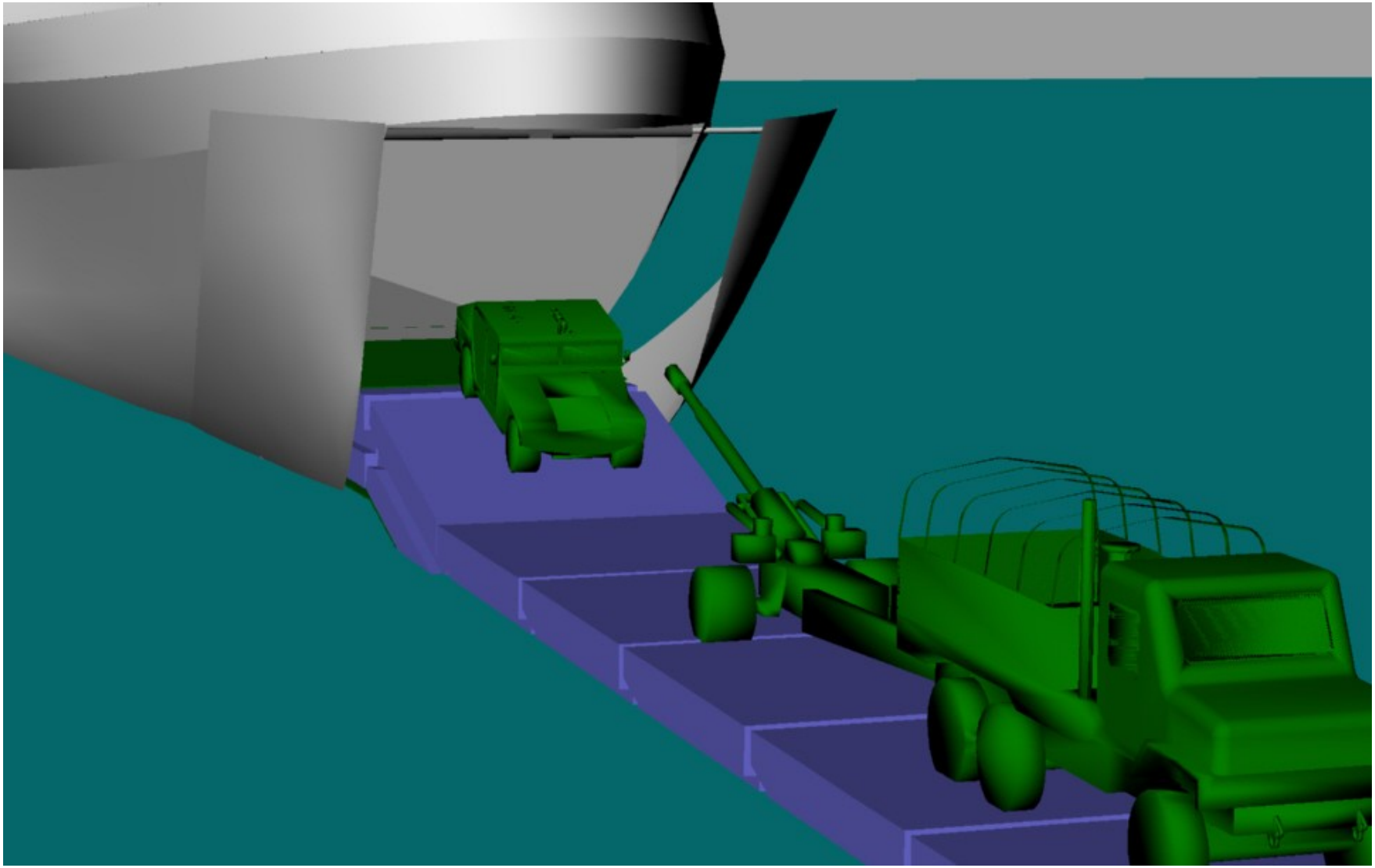
Cargo Layout



Flight deck Elevator

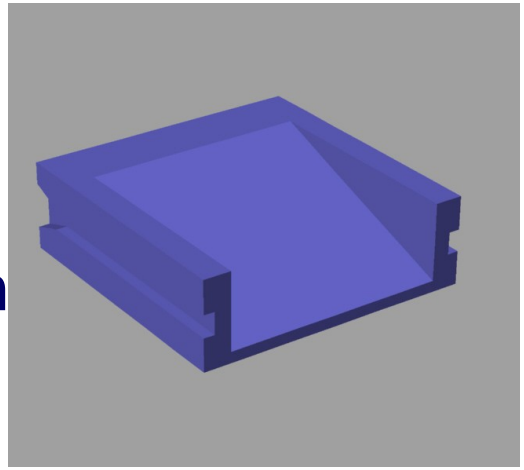


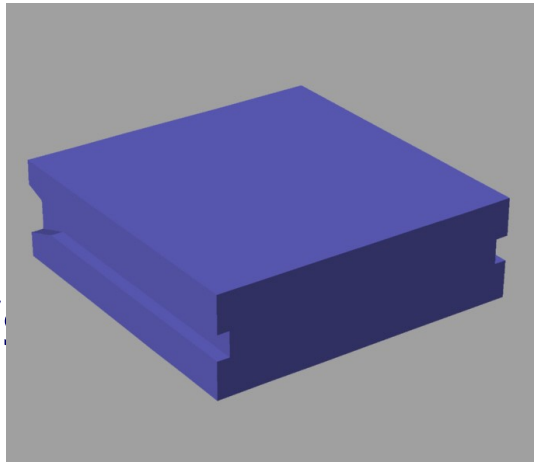
Bow Doors



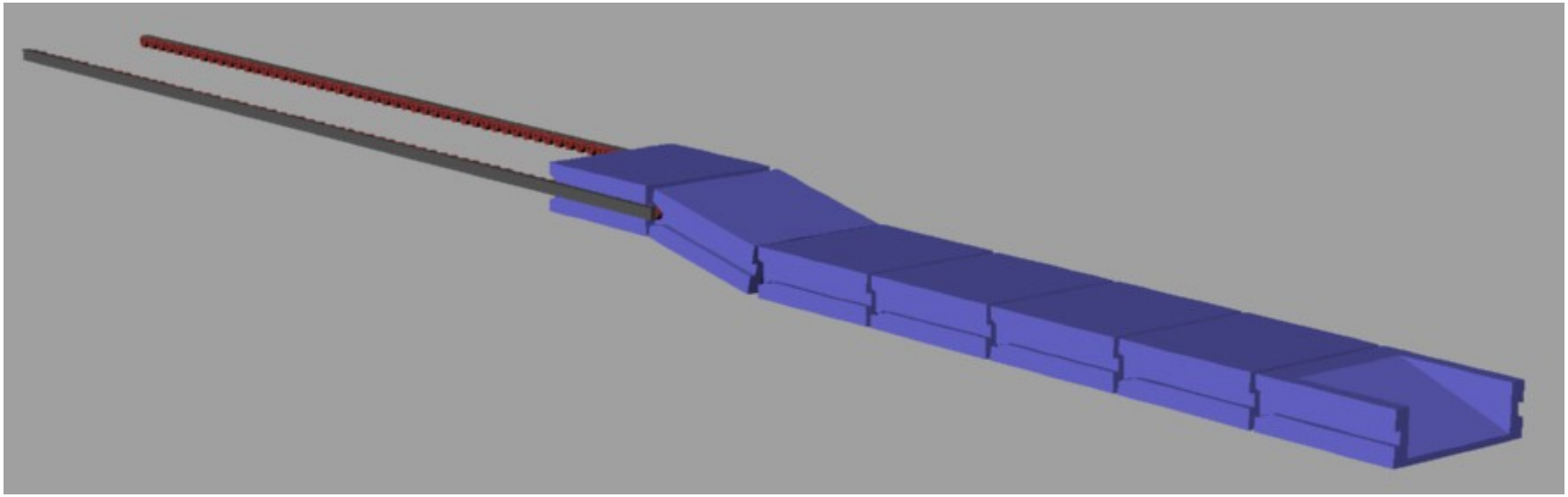
Bow Ramp

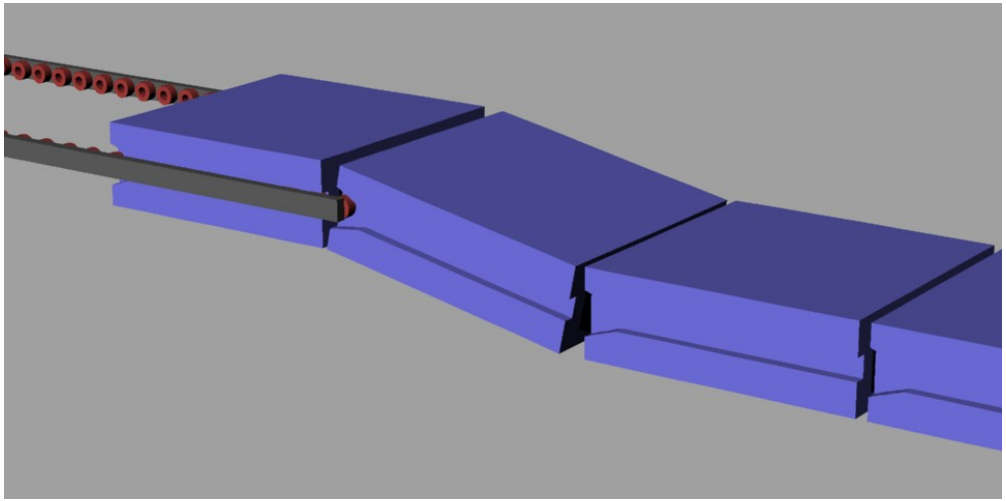
- Sectional floating causeways
  - Maximum deployed length = 35m
  - (8) 5m x 5m x 1.6m sections
  - Allows variable deployment length
  - Supports maximum load of (2) M1A2 Tanks
- Stored below lower cargo deck
- Mechanical deployment and recovery
  - Deployment/recovery rate = .2 m/s
  - Maximum length deployment ~ 3min





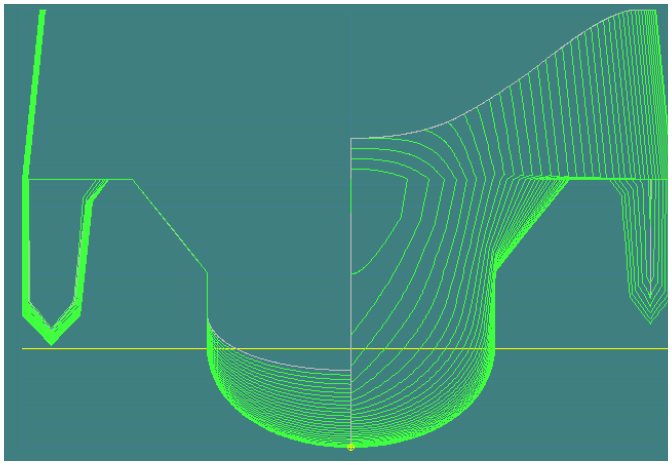
Bow Ramp

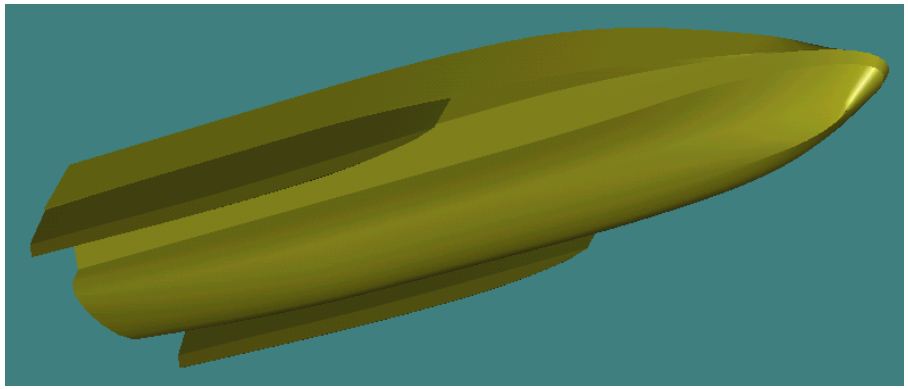


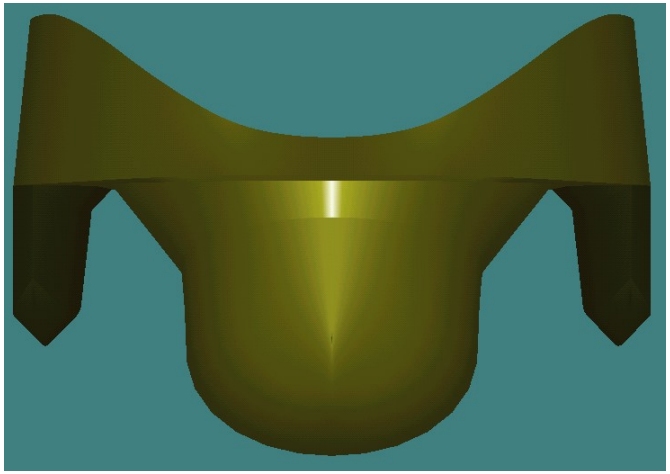


Selected Hull Form

- Wetted surface = 4300m^2
- Length = 149m
- Beam = 13m
- L/B = 11.5
- Froude number = .51
- Draft = 4.5m

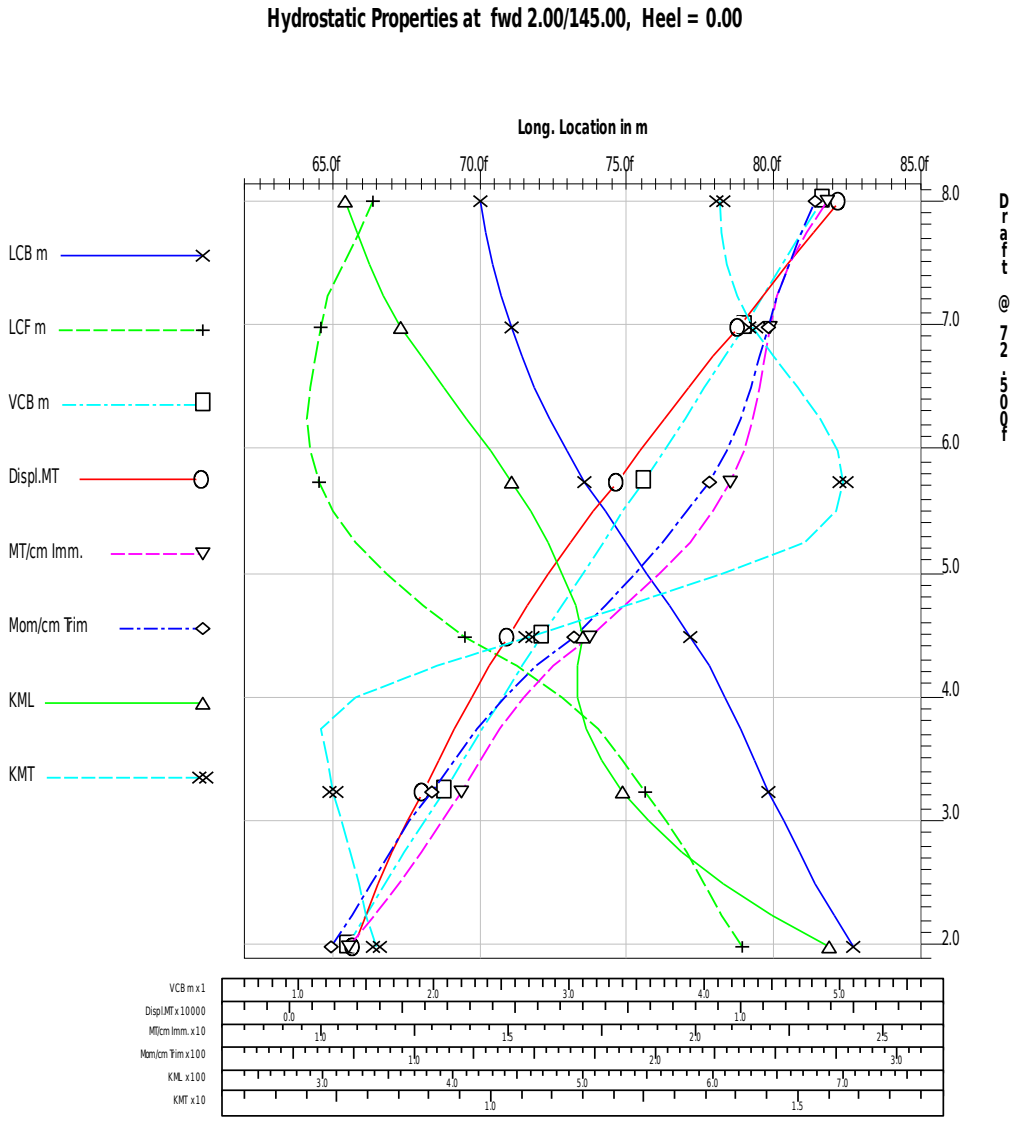






Calculations

- Hydrostatics
- Cross curves
- Tankage
- Stability
- Damaged stability



Power Requirements

- Combat systems and other electric loads: 2 MW
- Propulsion:

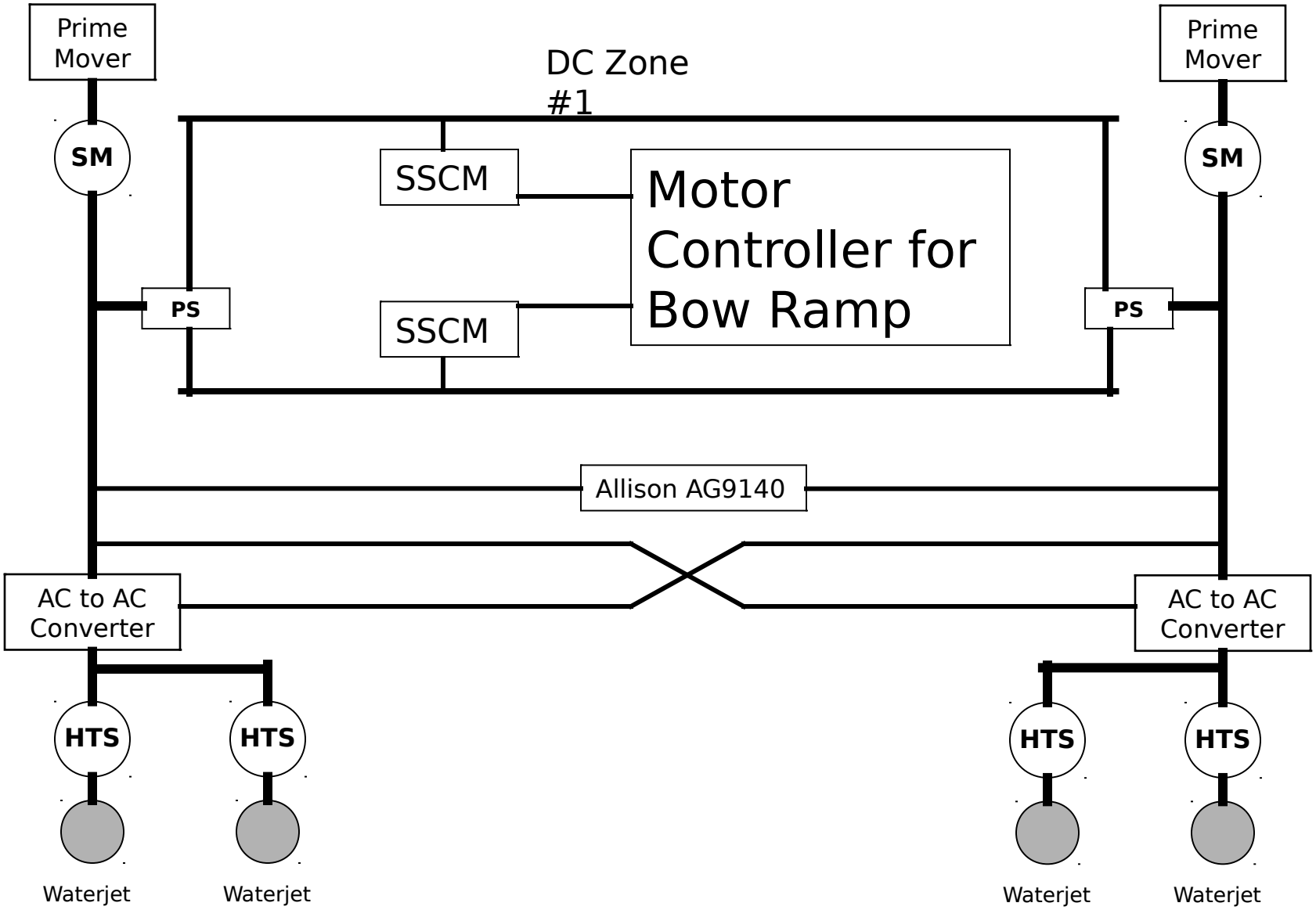
Speed (kts)	Power (MW)
10.95	0.88
16.43	3.29
21.91	10.37
27.39	16.31
32.86	26.35
38.34	40.35
43.82	58.25

Total power for 43 knots: 60 MW

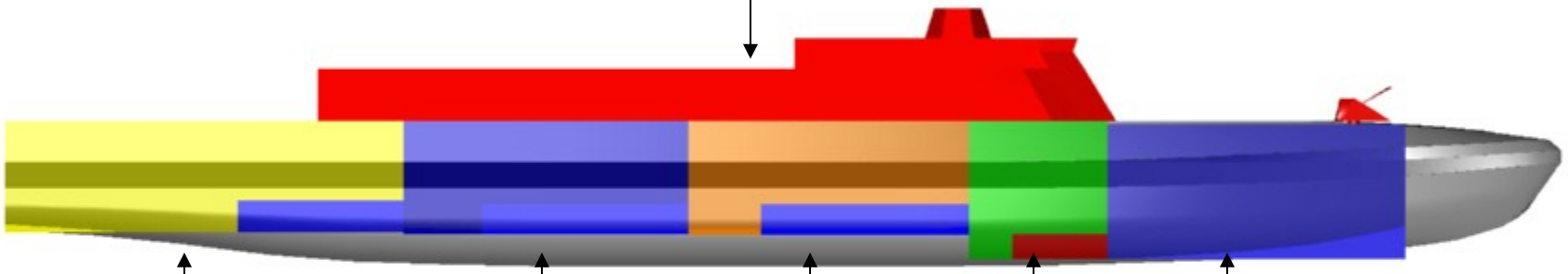
Propulsion: AoA

- Gas turbines selected
  - Power/weight
  - SFC
  - Efficiency
  - Reliable, proven technology
- (2) LM2500+ selected
  - High power/weight
  - Low volume
  - High power
  - Low SFC
- IPS
  - 4 AWJ21
  - 4 HTS AC synchronous motors

Electric Distribution

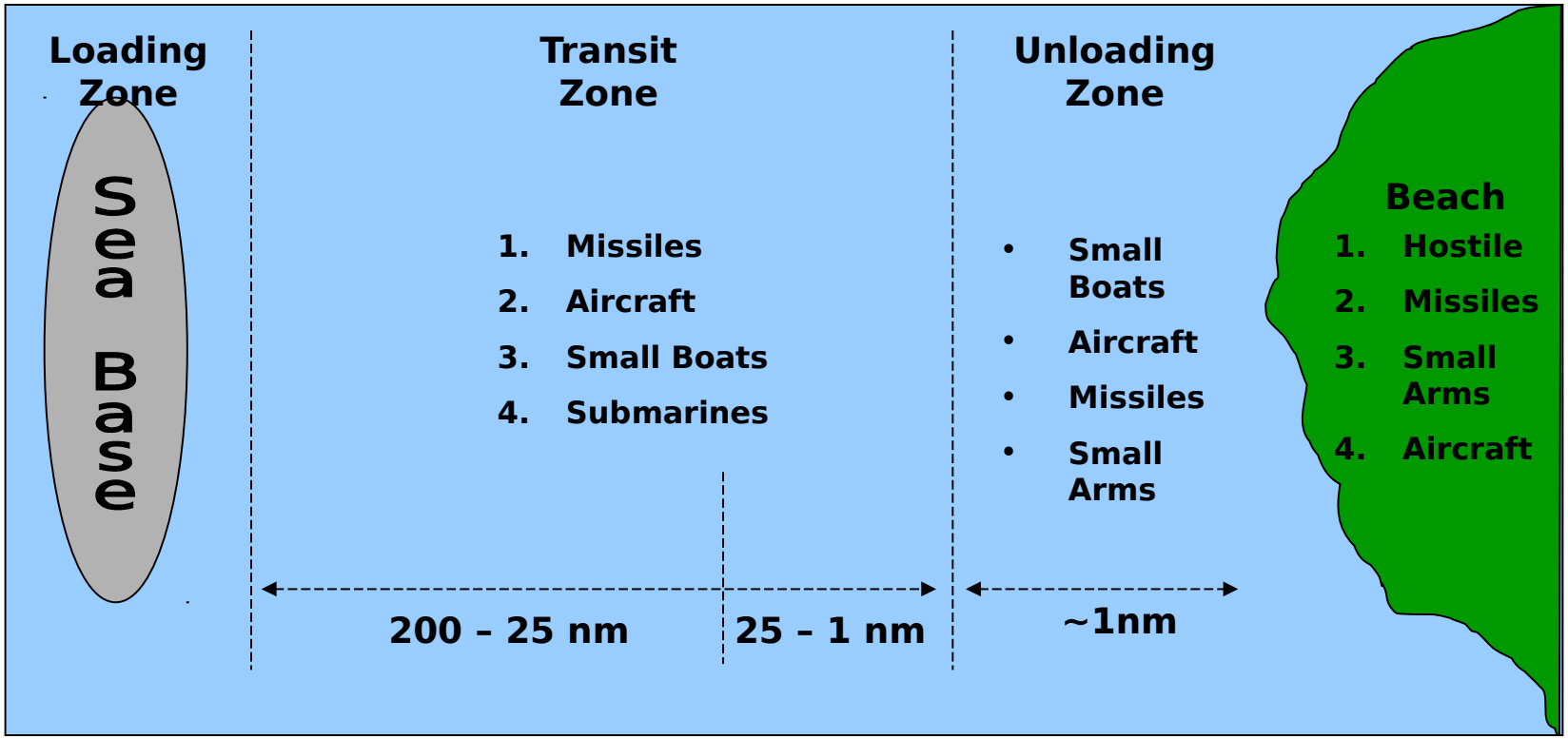


DC Zones


Zone 6:Superstructure
Zone 4:ER #2
Zone 2:CSER #1
Zone 5: Aft ER
Zone 3:ER #1
Zone 1:Bow Ramp

Threat Engagement Zones

- Open ocean to 25 miles from off-load zone
- 25 miles to 1 mile from off-load zone
- Less than 1 mile from off-load zone



Threat Matrix

	MFR	EO System	EW Suite	HPMDS	ESSM	57mm Gun	Twin M240
Aircraft	✓	✓	✓		✓	✓	
UAV	✓	✓	✓		✓	✓	✓
SAM	✓		✓		✓	✓	
ASCM	✓		✓		✓	✓	
Shore Fire		✓	✓	✓		✓	✓
Small Boats	✓	✓	✓	✓	✓	✓	✓
Mines		✓					

✓ Detection

✓ Passive Detection Soft Kill

✓ Hard Kill

Empirical RCS Calculation

- Based on Skolnik Empirical Method for low grazing angles

$$s = 1644 F^{0.5} D^{1.5}$$

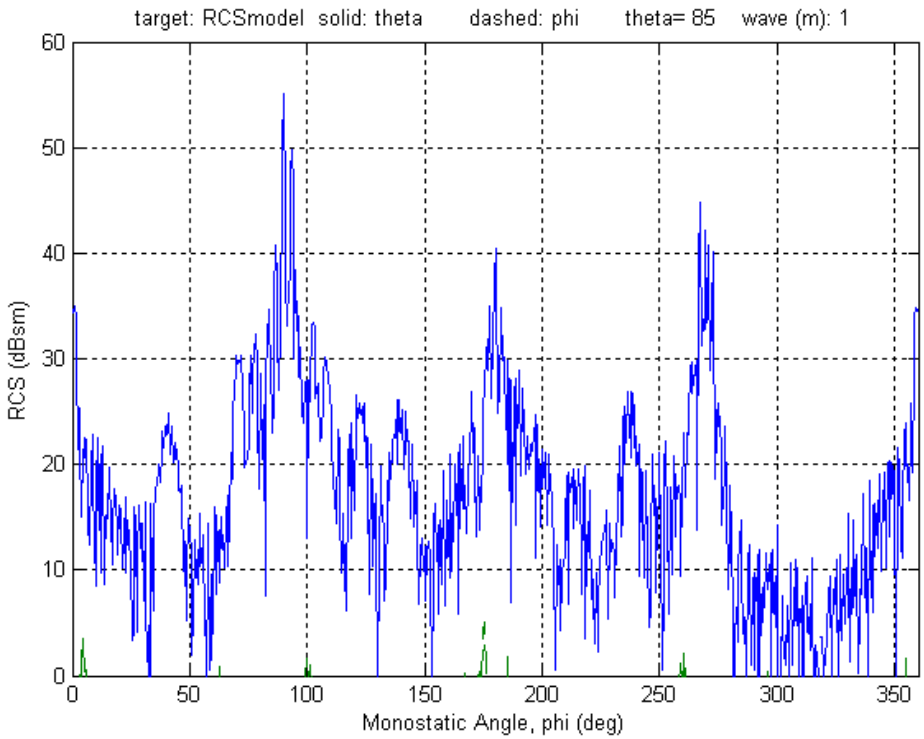
D displacement (kilotons)

F frequency in GHz

$$Median\ RCS_{SHIP} = 1644 \times 0.3^{0.5}_{GHz} \times 5^{1.5}_{Ktons} = 10067 = 40 dBsm$$

- To account for aspect angle, actual RCS approximation will vary between
  - 32dBsm (minima)
  - 53dBsm (for broadside)

POFACETS RCS Calculation

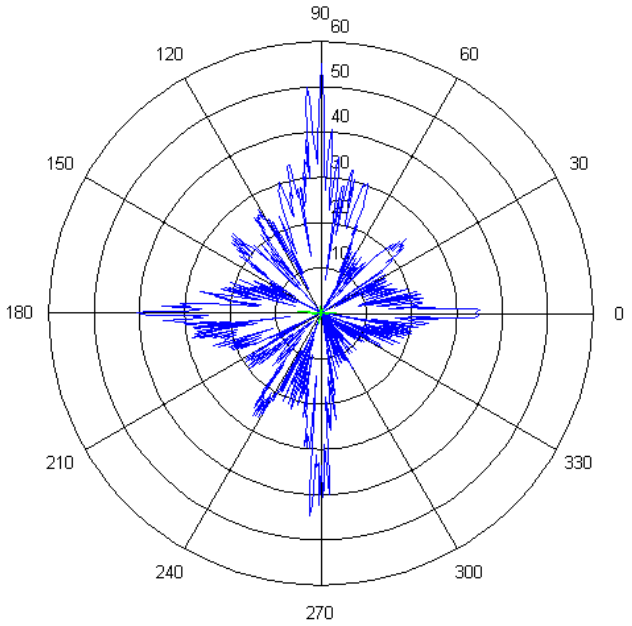


POFACETS
Version 3.0 (2004)

Professor David C. Jenn
Naval Postgraduate School

Commander Elmo E. Garrido Jr.
Philippine Navy

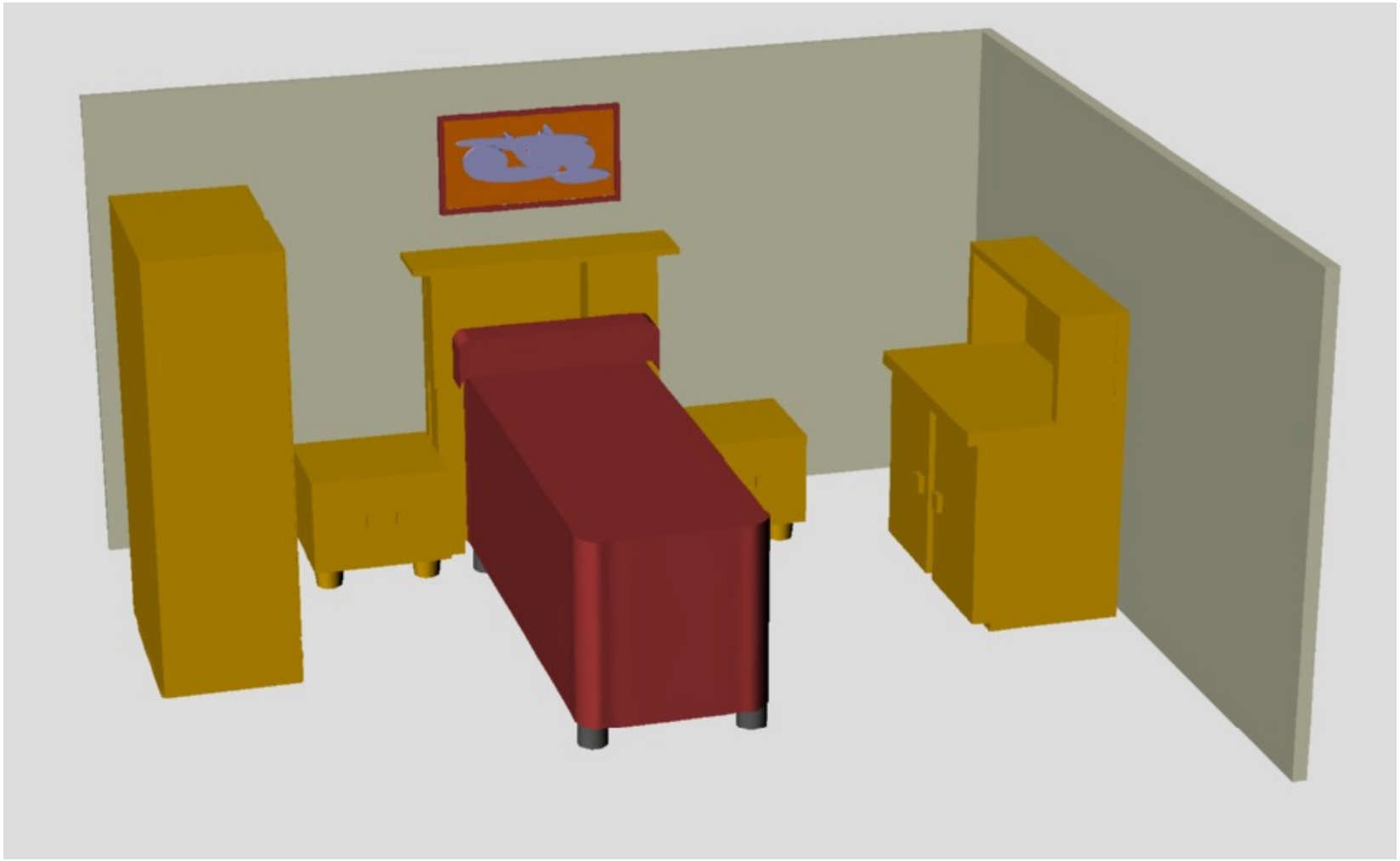
Major Filippos Chatzigeorgiadis
Hellenic Air Force



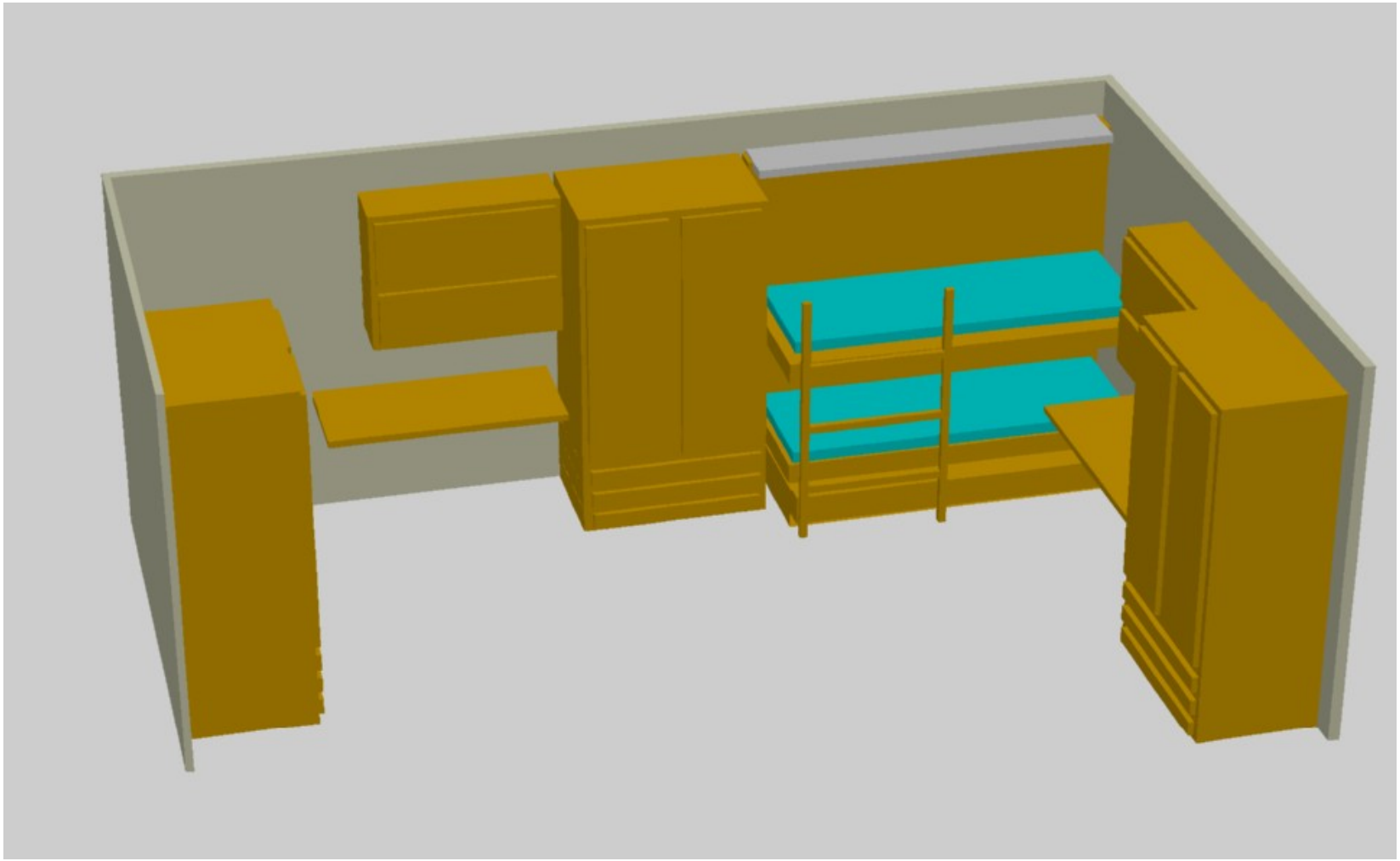
XPATCH RCS CALCULATION

- Provide DoD baseline measurements
- Due to distribution restrictions, program was run independently
- Results were compared with previous two methods and agreement was deemed satisfactory

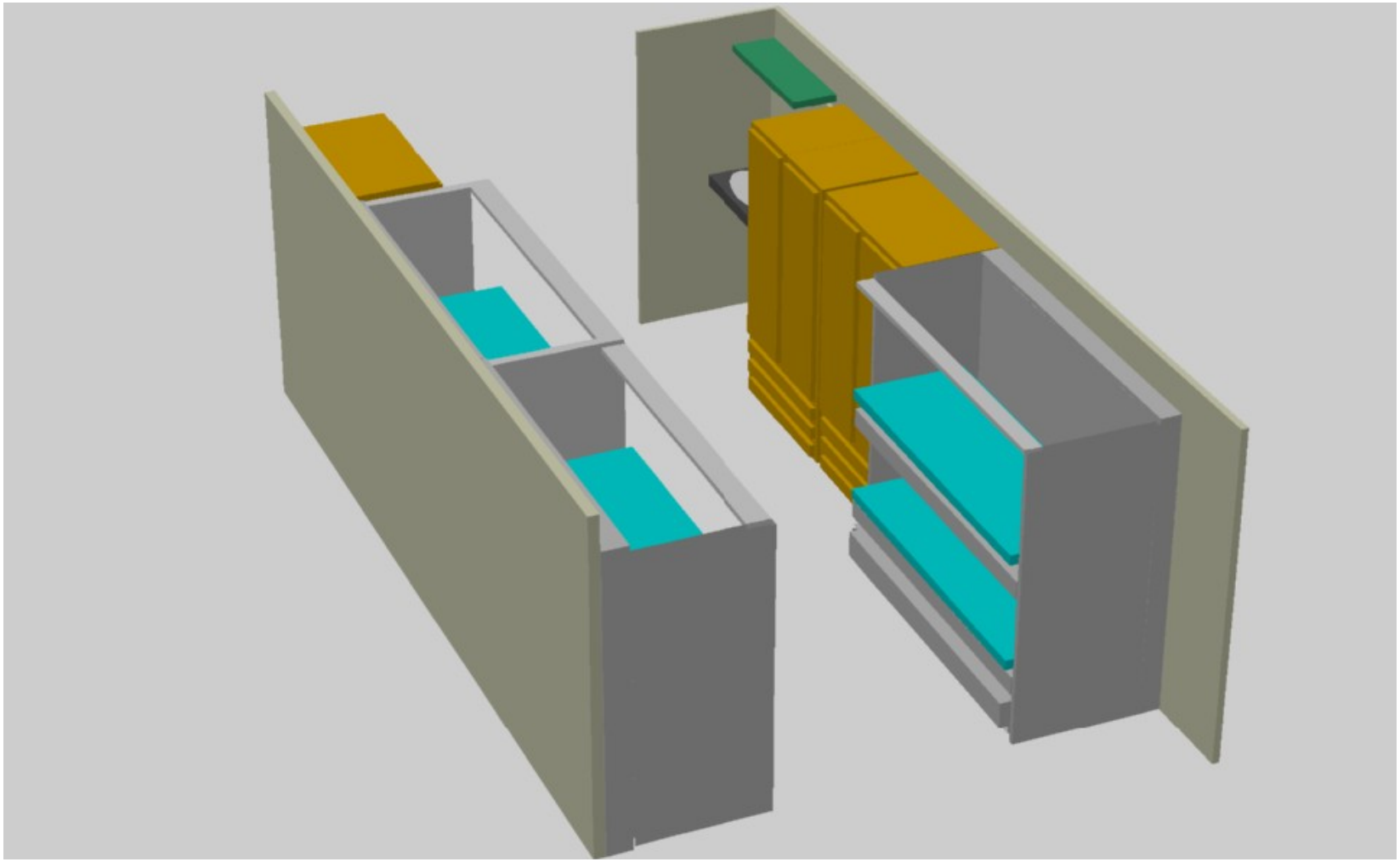
CO Cabin



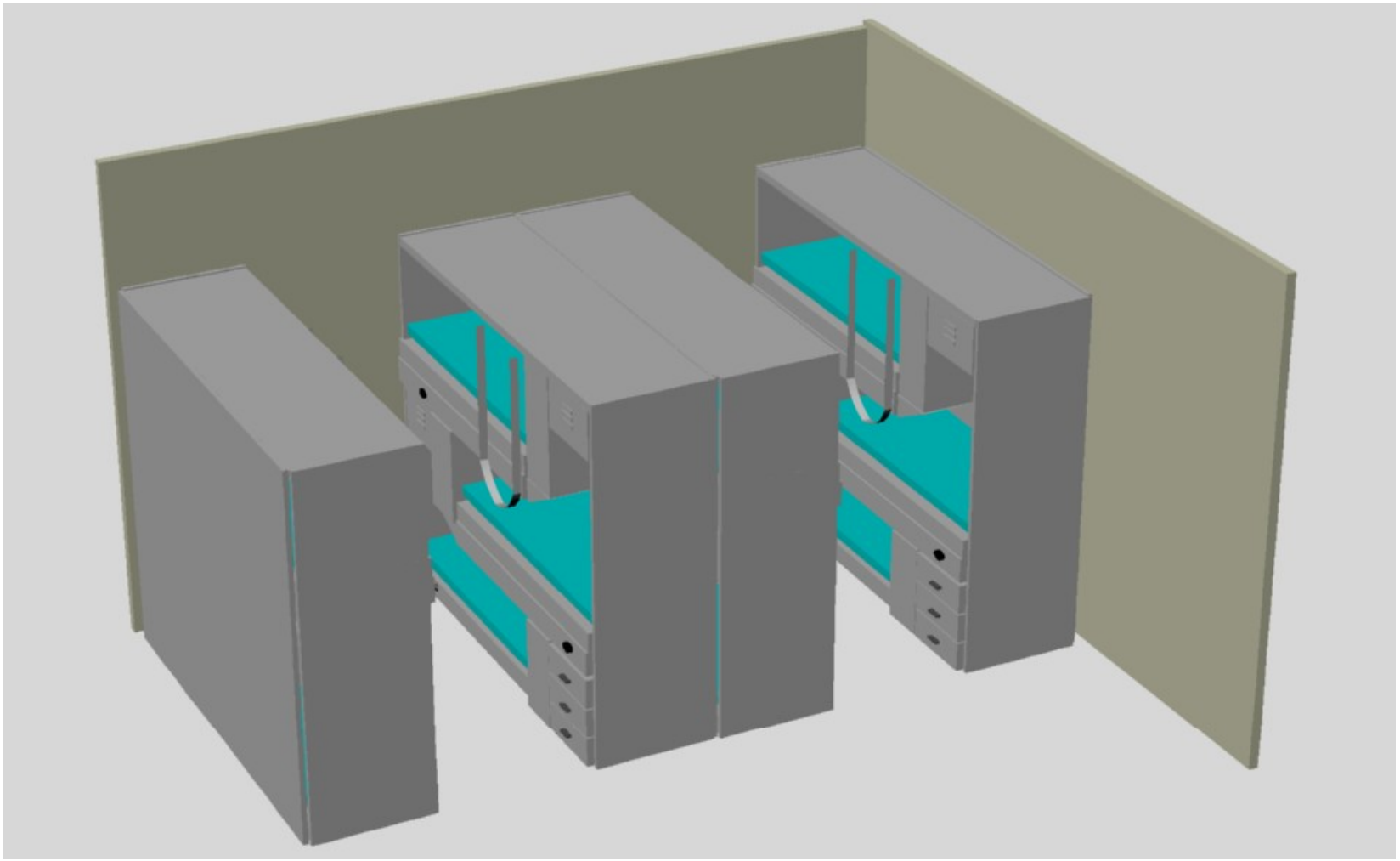
USN Officer Stateroom



CPO Berthing

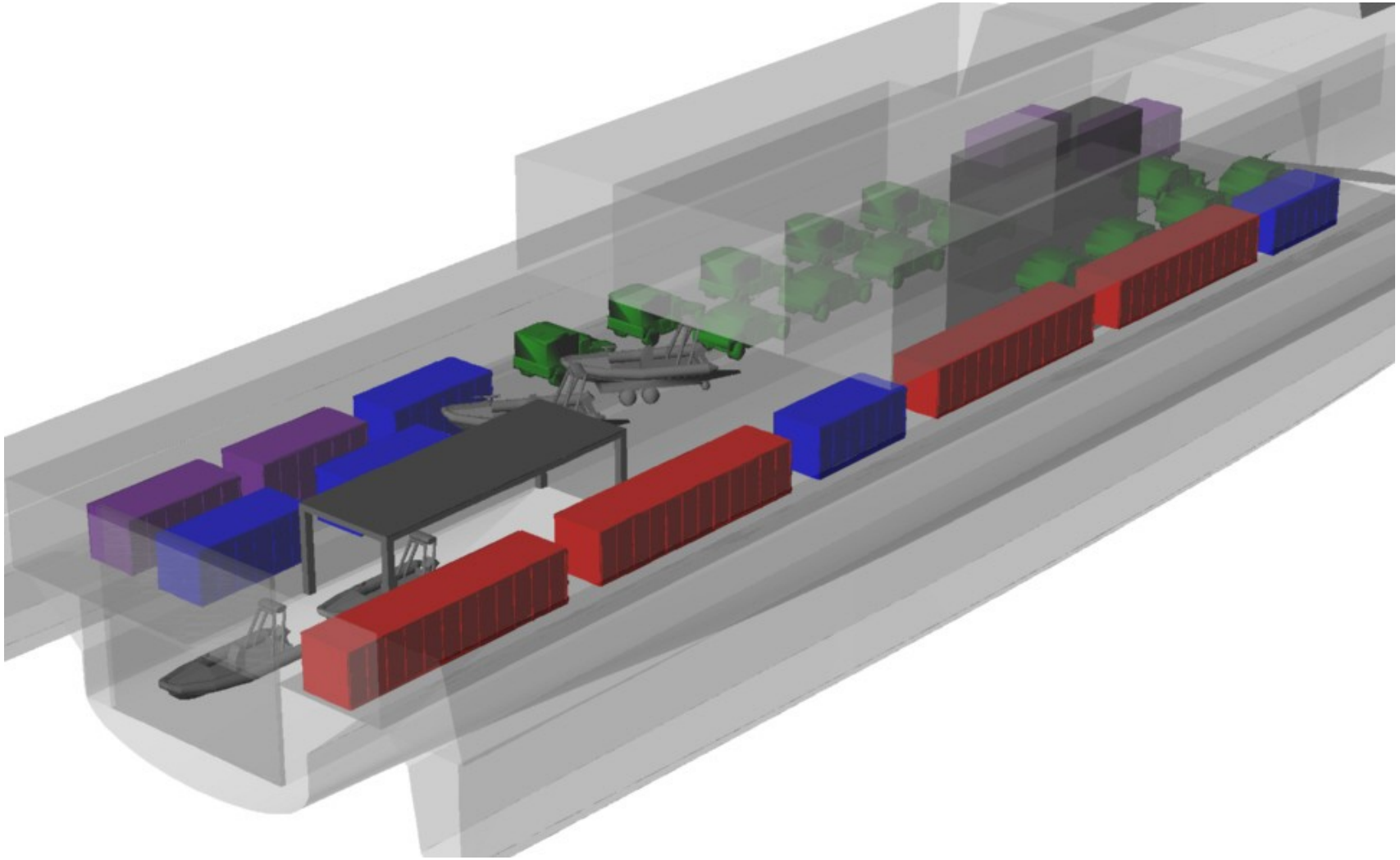


Enlisted Berthing



12 Person Berthing Compartment

Secondary Missions



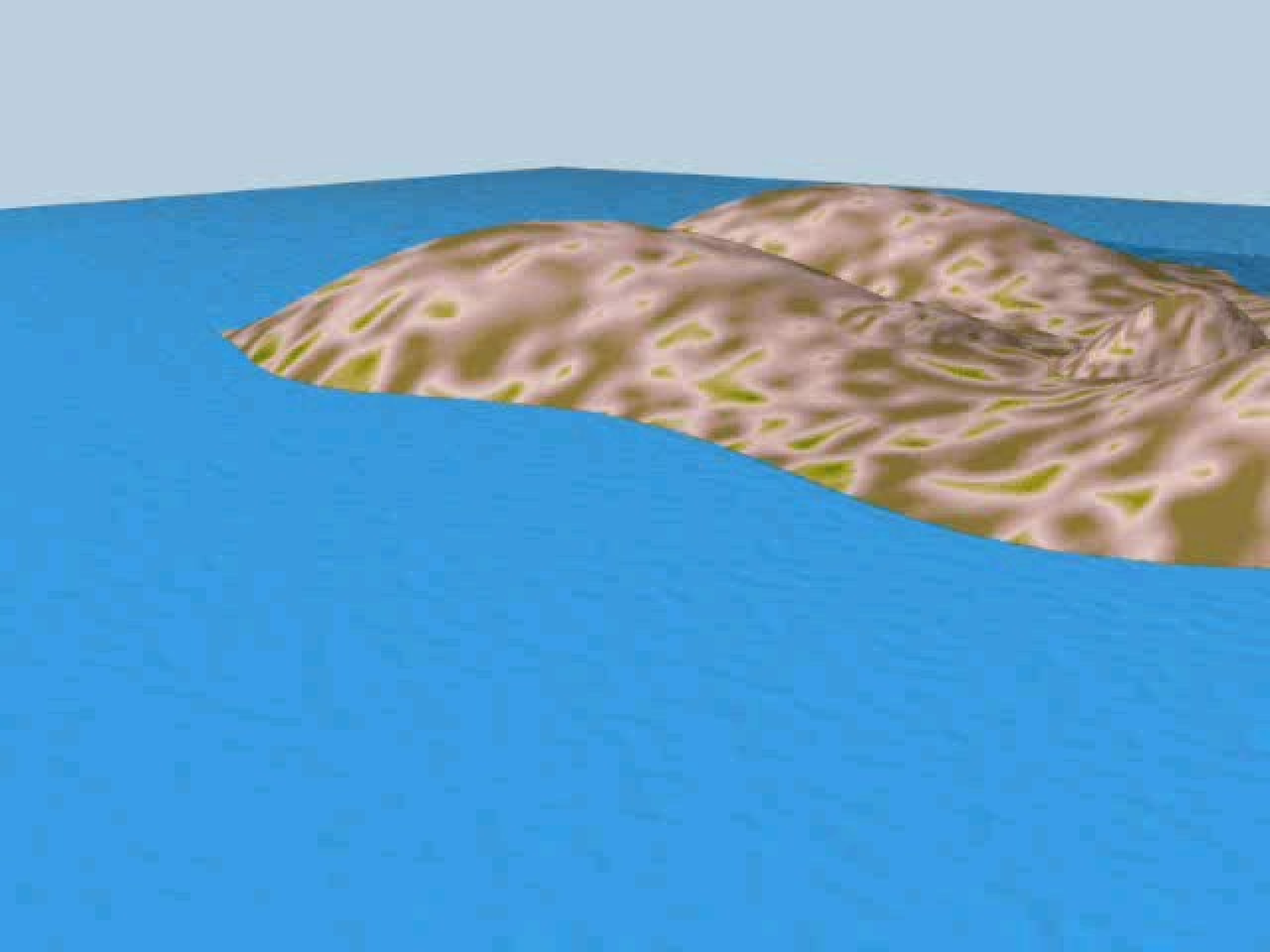
Ship Characteristics

- Overall length: 149m
- Overall beam: 30m
- Maximum draft: 4.5m
- Full load displacement: 4966LT
- Light ship displacement: 3124LT
- GM: 7m
- Maximum speed: 43kts
- SHP: 78,000hp
- Cruise range: 2600nm @ 34kts
- 1 Dedicated SH-60R hangar
- Crew compliment: 66

Conclusion

- TSSE acknowledges that we were unable to perform a thorough analysis on all technical issues that exist with every ship design

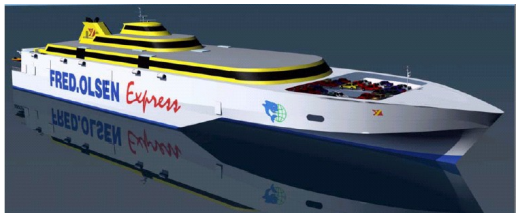
- TSSE believes that to achieve the HSAC mission displacement craft such as the Joint ACCESS need to be researched



Back-ups

Trimaran Feasibility

- Existing or projected trimarans
  - Length/beam ratio ~ 13 - 15
  - Froude number ~ 0.4 – 0.5
  - Payload ~ 30 - 40% displacement
  - Overall length ~ 140 - 160m



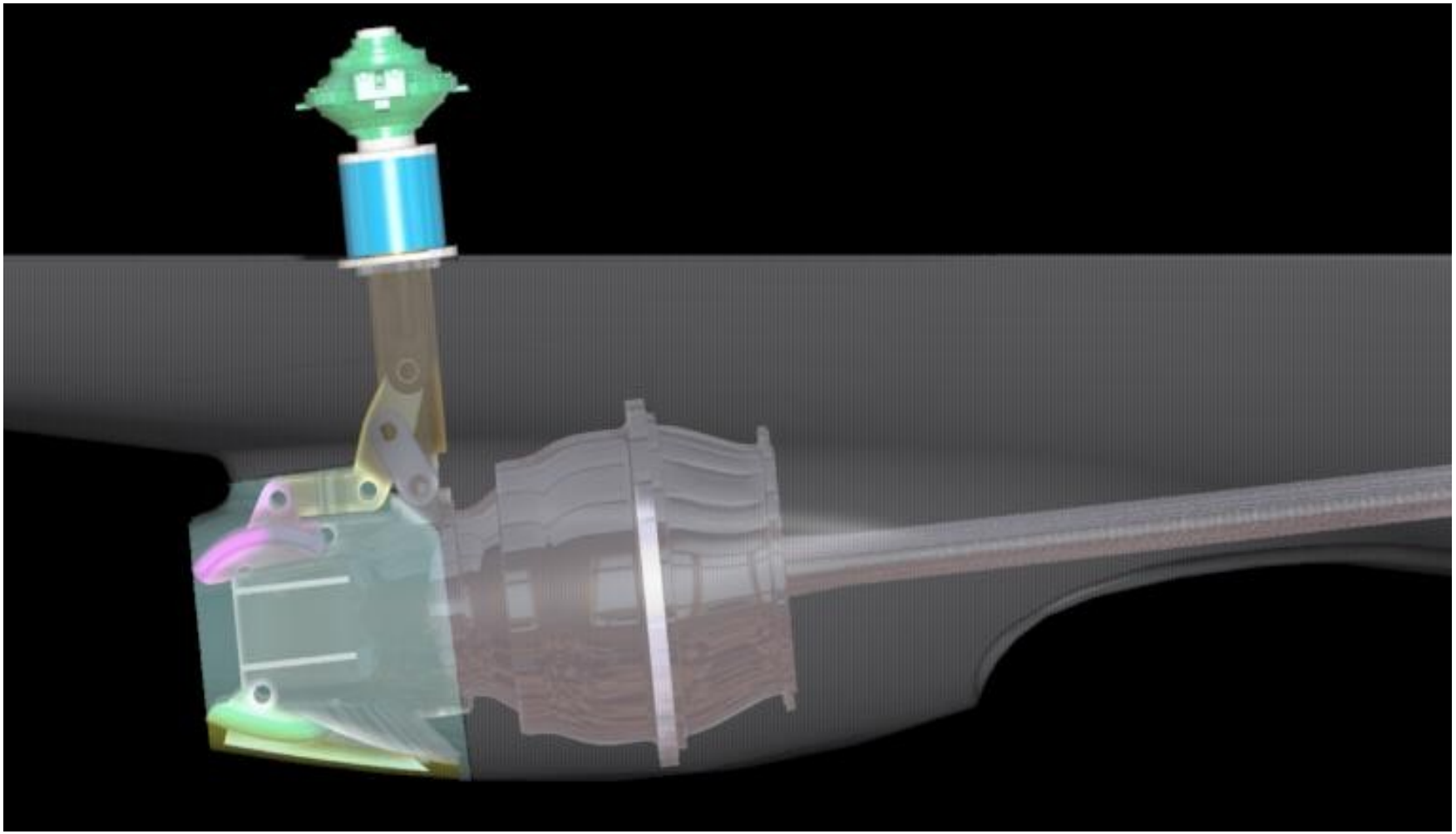
http://www.gomeralive.de/fred-olsen.4021.0.html

LOA (m)	LWL (m)	BWL (m)	T (m)	D	CN	Vol (m3)	Light (Ton)	LCB (m)	LCF (m)	Cp	Cm	L/B	B/T	Δ/VOL$^{1/}$	PAY	%	HP x1000kW	Vs (knots)	Fn	Range NM
301	301	19.6	9.8		57778	24160		142.4	125.7	0.6		15.3	2.0	10.4	9750	**0.40**	150.0	40.0	0.38	4000
122	122	9.4	3.7		4190	2186				0.5	0.8	13.0	2.6	9.4					0.00	
127	115														711			40	0.61	
105	95	7.3	2.5		1736	764	596					13.0	2.9	10.4	187	**0.24**	10.962	36	0.61	
140	140	9	4	0	4222	1983	1016					16.3	2.5	11.1	1000	**0.50**	22	40	0.56	
165	155	10	5	11	7134	0						15.5	2.2		813		52		0.00	
120	120	7	3	8	2498	1339						18.5	2.0	10.9			20	36	0.54	
105	105	7	3	9	2429	1120						15.4	2.0	10.1			20	38	0.61	
300	300	37	9		104340	25135	10310					8.1	3.9	10.2	14825	**0.59**	360000	55	0.52	

Electric Drive

- Pros
  - Increased flexibility over mechanical drive
    - Long drive train not required
    - Prime movers' location not restricted
    - Power available for other uses
  - Increased fuel efficiency
- Cons
  - Not proven
- Electric drive selected

Propulsor: AWJ21



Source: http://www.rolls-royce.com/marine/downloads/pdf/propulsion/birdawj21.pdf

Propulsion Motor: AoA

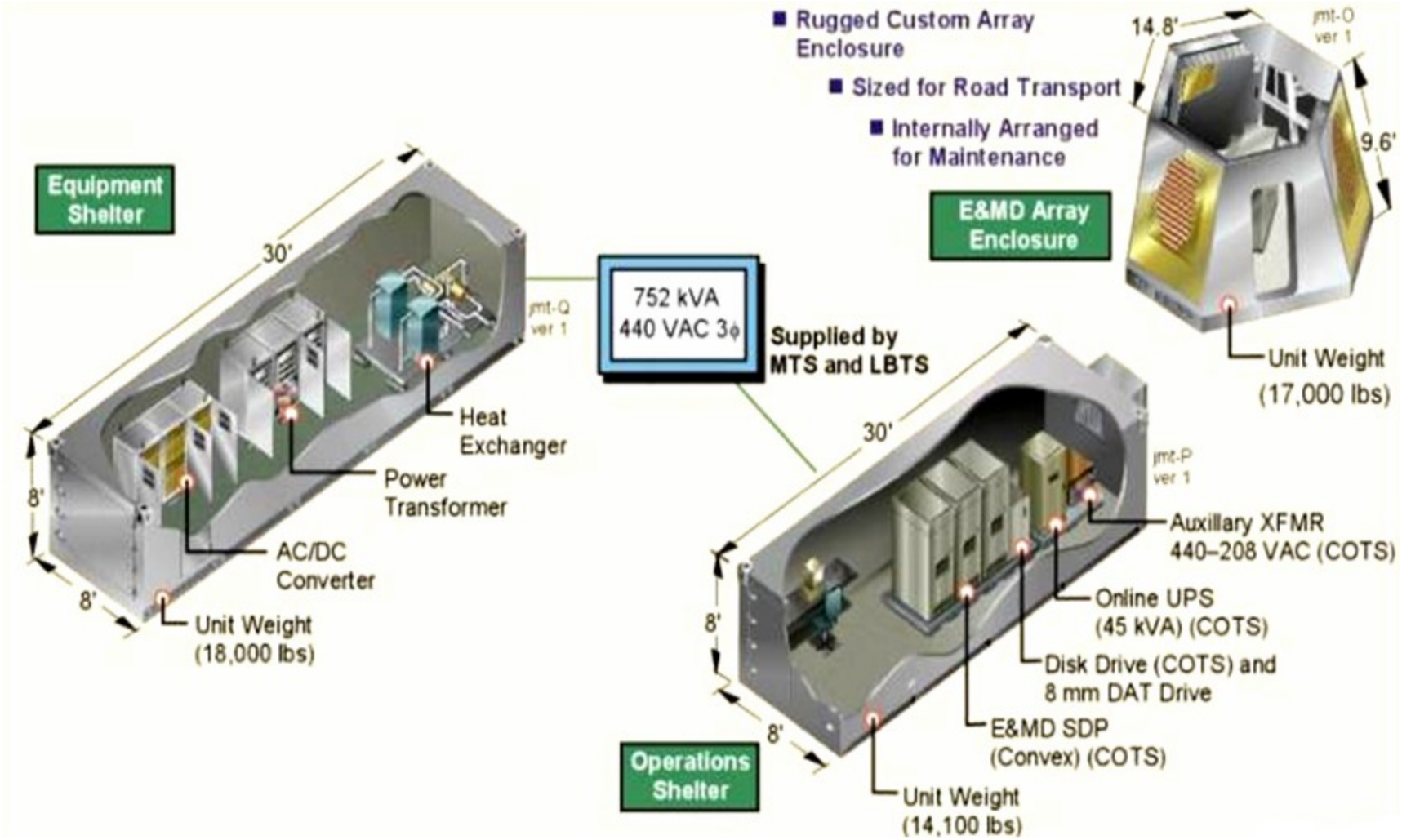
- Propulsion motor alternatives
  - Conventional motors
  - HTS AC synchronous motors
  - DC super conducting homo-polar motors
- HTS AC synchronous motor selected
  - Smaller size
  - Lighter weight
  - Acceptable technological risk

Source: Email with Matthew O'Conner, Sales Manager, American Superconductor Corporation, November 18, 2004

Ship Armament

- (32) Evolved Sea Sparrow Missiles
- (1) 57 mm Boforors Gun
- (2) High Power Microwave Active Denial System
- (4) M240C Machine Gun Mounts
- Electronic Warfare Suite

MFR

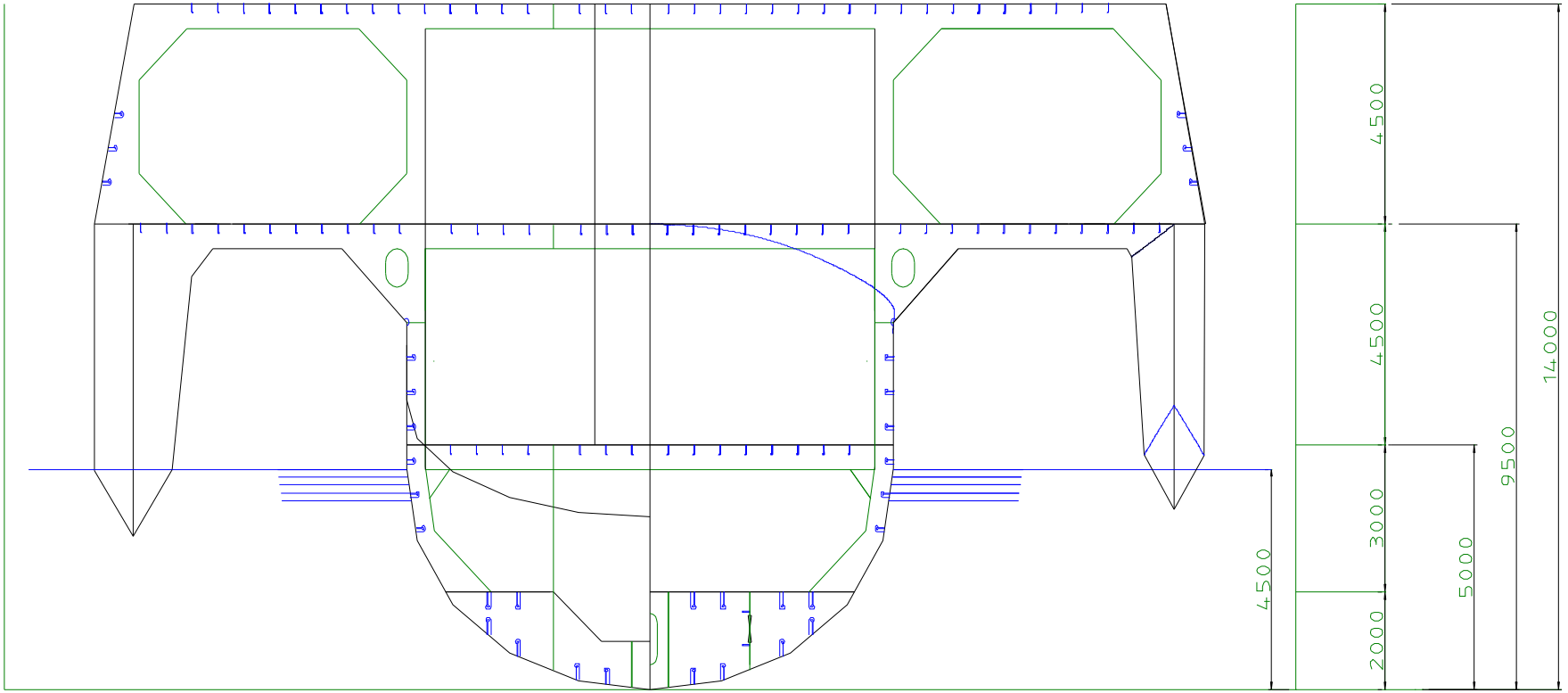


Source: TSSE 2003 Final Report

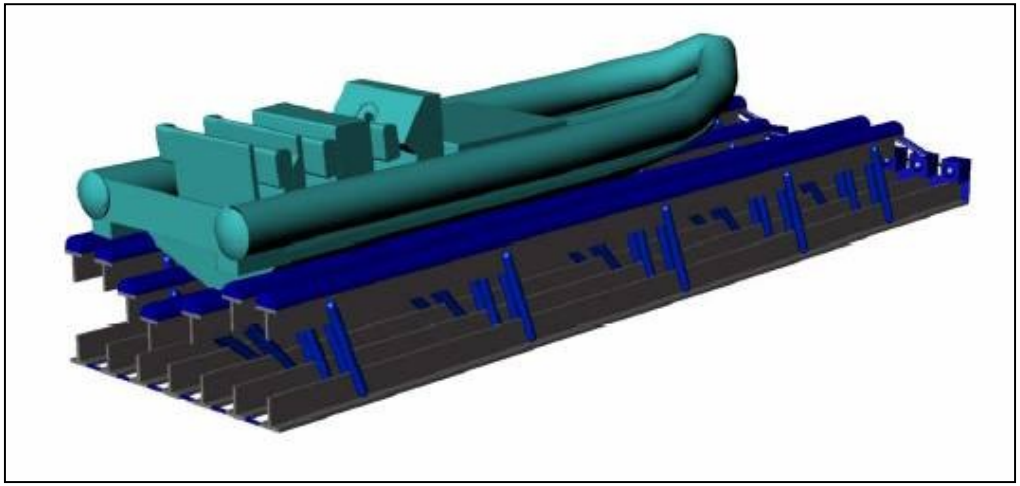
Weapons

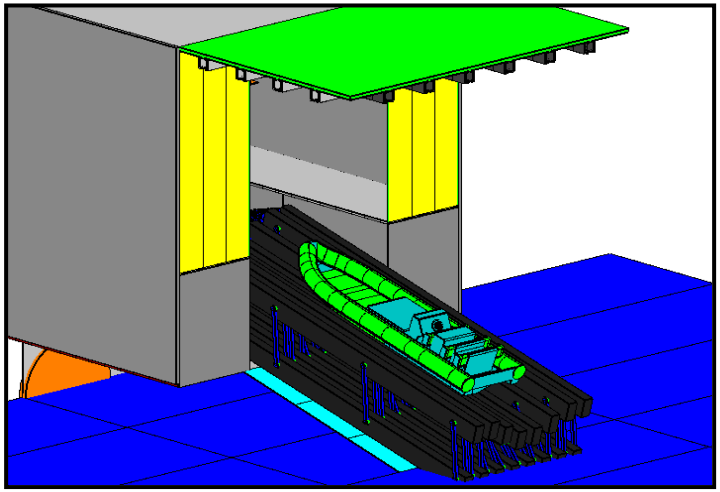
- Missiles
  - Primary Mission: Self Defense
- EW Suite (AN/SLY-2(V))
  - Advanced Integrated Electronic W System
- Thermal Imaging Sensor System
- Main Gun: Bofors 57mm

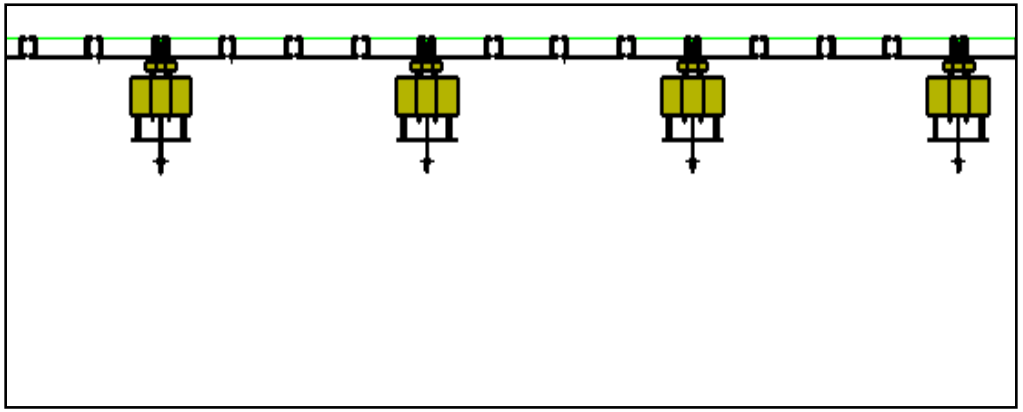
Structure

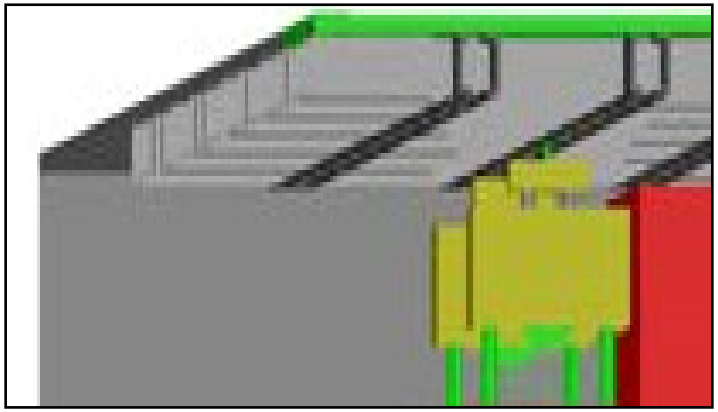


UV Handling









Source: NSWCCD- INCEN- TR- 2003/001

Weight estimation

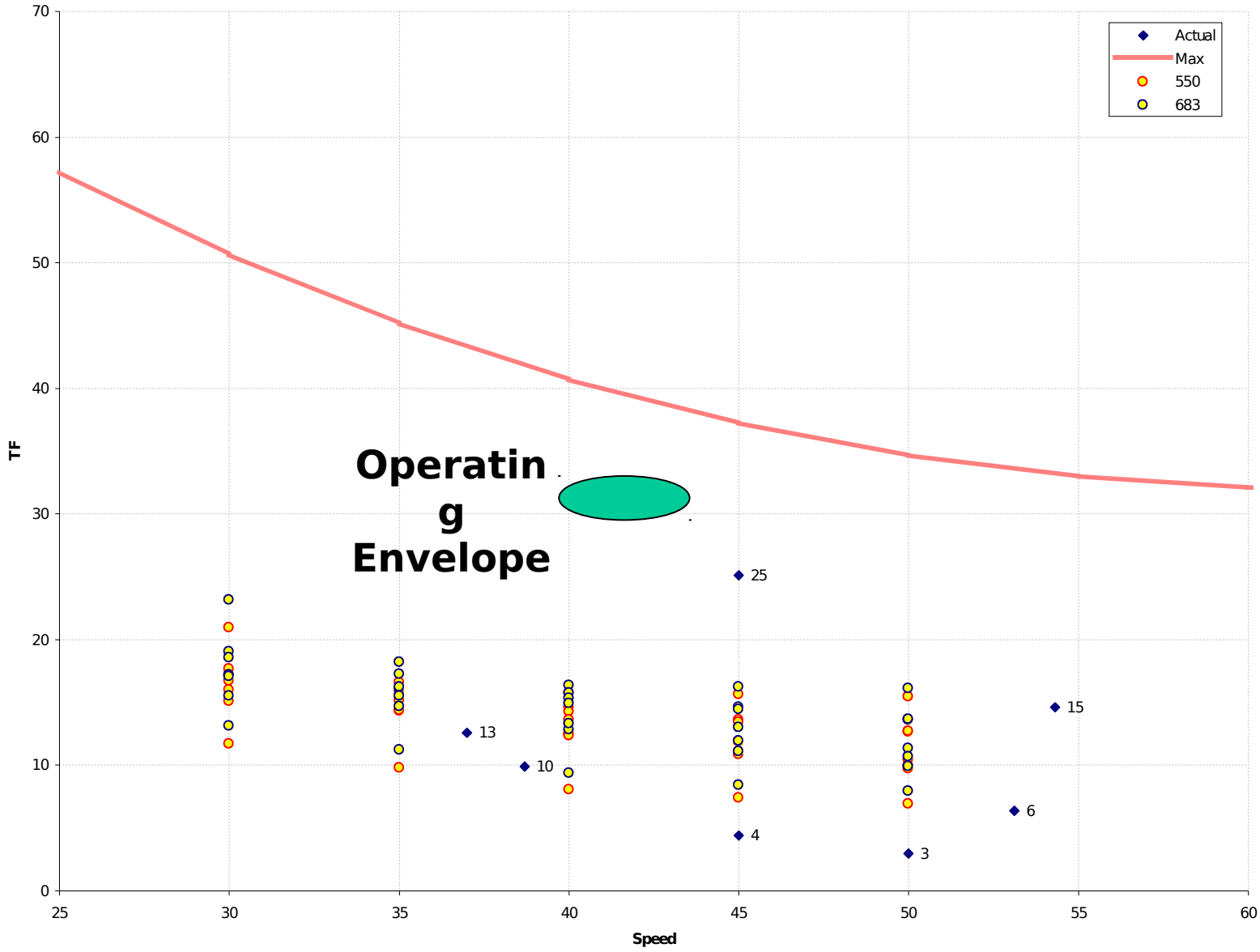
Group	Name	Weight (LT)
100	Hull Structure	1943
200	Propulsion Plant	91
300	Electric Plant	118
400	Command and Surv.	112
500	Auxiliary Systems	302
600	Outfit and Furnishings	159
700	Armament	164
Liquids & Storage		1022
6% Margin		235
Payload		820
Total		4966

Cost estimation

Assuming 12 ship construction and a learning curve exponent of 0.95

Concept	Cost (Mill $)
Ship Construction	156
Propulsion and Electric Distribution	230
Cargo Interfaces	10
Combat System	80
Total (For 1 Ship)	476

Reality Check



Ship Characteristics Reqs

- **Endurance for minimum one round trip from sea base to beach at full load and full speed**
- **Able to interface with developed and undeveloped ports, harbors and beaches to transfer cargo**
- **Able to interface with Sea Base and current Naval assets**
- **Must meet mission requirements at Sea State 5**
- **Able to transit 2000nm in less than 8 days in sea state 5 (wave height 8-12 ft) without replenishment**
- **Able to operate in shallow water without degradation in performance**
- **Able to Replenish-at-Sea (RAS)**
- **Full accommodations required for embarked crew**
- **Fuel and support rotary wing aircraft supporting amphibious operations both day and night**
- **Minimal manning**
- **Able to transit 2000nm in less than 10 days in up to sea state 8 (wave height 25-40ft) without replenishment**

Cargo/Interface Reqs

- **The HSAC System of Systems must provide minimum lift capacity of 7,963 tons (including EFV transport).**
- **The HSAC System of Systems must provide minimum deck area of 98,163 square feet (including EFV transport).**
- **The HSAC must be capable of offloading cargo to beach and/or unimproved pier.**
- **The HSAC must be capable of interfacing with LPD, LHA, LHD, LSD, and MPF(F) class ships.**
- **The HSAC cargo area must be dimensioned to a minimum height requirement to handle and store a standard 20ton TEU (8'6")**
- **THE HSAC must be capable of providing interfaces and services to payload (i.e. electrical power, data-link, fueling)**

Combat Systems Reqs

- **Defend against/destroy small (less than 200ft long), high speed (in excess of 40kts) surface craft**
- **Detect, track, and destroy up to 8 simultaneous “leaker” missiles**
- **Sustain hostile small caliber fire**
- **Provide suppressive fire for amphibious forces**
- **Communicate with U.S. and coalition forces via both secure and unsecure channels**
- **Provide a data link capability**
- **Collect, process, display, evaluate and disseminate tactical information**
- **Conduct evasive torpedo maneuvers**
- **Employ ASW countermeasures**
- **Detect, track, and identify UAV, low slow flyers, attack aircraft**
- **Provide Naval Surface Fire Support (NSFS) for amphibious forces**
- **Detect, track, and identify surface threats to the horizon**
- **Provide for surface defense of Area of Assault (AOA)**
- **Defend against and engage hostile UAVs and low slow flyers (less than 200kts)**
- **Conduct Electronic Protection Operations**
- **Deconflict potentially hostile craft from friendly and neutral shipping**
- **Detect and avoid underwater mines**
- **Fuel and support rotary wing aircraft both day and night**

Initial Input

Ranking			
1	Desired Speed in Waves	60	knots
2	Desired Payload	1,200	long tons
3	Desired Range	4,000	nautical miles
	Sea State	1	wave height at top of SS1 = 0.3 feet
	Maximum Displacement	12,000	long tons

Results		Hydrofoil	HYSWAS	SES	Semi-Planing Monohull	Catamaran	Trimaran	SWATH
Calm Water Speed [3,12]	knots	60.0	60.0	42.0	60.1	60.0	60.1	60.0
Speed in Waves [1,3,4,9,10,11]	knots	60.0	60.0	42.0	60.0	60.0	60.0	60.0
Payload Weight [2,3,4,9]	long tons	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Range at Speed in Waves [4,7,9]	nautical miles	4,000	4,000	3,483	2,404	4,000	4,000	1,994
Displacement [3,7]	ylong tons	7,871	8,424	11,828	7,508	10,633	10,649	8,508
Installed Power [3,6,7]	HP	209,682	239,172	330,000	342,000	280,915	300,089	342,000
Engines [5]	ylong tons	6 LM 2500+	6 LM 5000	6 LM 5000	6 LM 6000	6 LM 5000	6 LM 5000	6 LM 6000
Fuel Carried On Board [3,7,8]	ylong tons	2,082	2,651	3,749	2,406	2,778	3,000	1,844
Length	feet	478	380	620	430	518	798	330
Beam	feet	121	110	116	86	166	193	146
Hullborne Draft	feet	65.7	53.2	25.6	31.9	23.6	20.0	30.3
Foilborne / Cushionborne Draft	feet	26.6	28.2	7.2	N/A	N/A	N/A	N/A
Rough Order of Magnitude Cost		$528,900,000	$531,300,000	$582,600,000	$543,000,000	$564,000,000	$573,200,000	$572,100,000
Lift to Drag Ratio		23.8	19.4	15.9	12.4	21.7	21.2	12.1

Elimination of Designs

5 ships							
	Hydrofoil	HYSWAS	SES	Monohull	Catamaran	Trimaran	SWATH
	1	2	3	4	5	6	7
30	0.2754515	0.3129188	0.314196	0.2857599	0.3170344	0.4363471	0.324023
35	0.3046338	0.3230334	0.321749	0.3016299	0.3449727	0.4213841	0.327652
40	0.3316624	0.3353557	0.333362	0.3145332	0.363817	0.4134794	0.331671
45	0.3569973	0.3493864	0.347695	0.3267372	0.3823132	0.4149921	0.340801
50	0.3810333	0.3647655	0.363947	0.3397455	0.4008725	0.422562	0.353284
test1	0	0	0	0	0	0.4217529	0
test2	0	0	0.33619	0	0	0.4217529	0.335486
test3	0	0	0	0	0	0.4217529	0
old cost						483800000	
new cost						248334985	